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Building One's House of Adobe

by André Lachance



Improved adobe construction techniques offer better earthquake resistance

A foreigner arriving in Peru is always surprised at the number of adobe constructions, made from sun-dried bricks of mud. From grand colonial palaces to simple field enclosures, from the crumbling pyramids of the ancient Moche civilization to the humble homes of poor farmers, these non-fired bricks are an integral part of the Peruvian landscape, particularly along the Pacific coast where it hardly ever rains.

It is estimated that 65% of Peru's rural inhabitants, and at least a third of city-dwellers, live in adobe buildings, and often in ones that have been around for a long time. Adobe construction has many advantages: it is low-cost (less than half the price of conventional bricks), the raw materials (straw and clay) are readily available, it has excellent heat and sound insulating properties, and it is easy to produce.

For some years, however, adobe has been falling out of favour with Peruvian home builders. Many new structures are being built today of clay bricks or cement blocks.

"Adobe is looked down on today in all of Peru's villages", notes [Luis Zegarra Ciguero](#), with a touch of regret. Mr Zegarra is director of research in the engineering department of the Pontifical Catholic University of Peru, in Lima. "Bricks and concrete have become something of a status symbol. In Spanish, people say that these are 'noble' materials, while adobe is associated with poverty."

Earthquake zone

There is also a technical problem involved. In areas like the Andean Plateau that are subject to frequent

earthquakes, traditional adobe houses have a tendency to collapse all too readily. In fact, a quake in 1970 destroyed some 60,000 homes, killing more than 50,000 people and injuring another 150,000. When the ground shakes, adobe bricks are likely to crack and disintegrate, which causes the walls to collapse and the roof to fall in.

With the active support of IDRC, a team of three engineers and eight technical experts at the university has found a solution to this problem. In addition to using bamboo poles to reinforce the walls, Luis Zegarra's team has discovered that the simplest and most effective way to keep the roof from collapsing is to place a solid wooden plank on top of each of the walls. The roof beams then rest directly on these planks, and the weight is evenly distributed so that the walls have a better chance of withstanding an earth tremor.

Once this technical problem had been resolved, there was still the question of persuading people to trust this "new" product. This step posed a considerable challenge, in light of the poor popular perception of adobe, which is considered an inferior material not only by potential home-buyers but also by mortgage lenders. With IDRC's assistance, a number of adobe bungalows have been built over the past few months at Piura, in the northern part of the country. The municipality offers the land at a good price, and the local credit union will advance buyers the money. For about US\$5,000, a family can find modern, healthful accommodation in a home measuring 55 square metres. The total cost, which includes interior finishing, doors, windows, and bathroom, works out to approximately \$100 per square metre -- a bargain, even in Peru, where the shortage of affordable housing is estimated to be at least a million units.

"Do-it-yourself"

While the bungalows at Piura were put up by a local contractor, the system has been designed with the do-it-yourself builder in mind. "The idea is that if people can build a traditional adobe home, they will in fact be building a better home", says Gladys Villa Garcia, who is in charge of the anti-seismic building research centre at the Pontifical University. "The construction technique is very simple. We have printed up several thousand brochures showing how to do it, step by step. Some of the houses built by this method in Piura have already found takers -- and they are very happy with their purchase! With all the publicity our research has attracted, people are really becoming interested."

André Lachance is a freelance journalist in Montreal who recently travelled to Peru.

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[Vol. 23, No. 4 \(January 1996\)](#)

A TILE SUCCESS STORY

by Khodia Ndiaye

Long considered a luxury item in Africa, tiles are regaining ground and emerging nowadays as a strong seller in Ivory Coast, thanks to the combined efforts of research and a definite political will to promote low-cost housing.

As in most neighbouring African countries, roofing materials in Ivory Coast are imported for the most part and are expensive. Roofing accounts for 30% of the cost of building a home in Ivory Coast and therefore entails major outflows of currency. These so-called modern materials, however, although recognized as effective and durable, are unsuited to the environment and encourage problems related to corrosion, heat and noise. Hence the preference, in urban areas, for metal materials, corrugated tin and sometimes reinforced concrete or terra cotta tiles. In rural areas traditional roofing materials, such as straw and palm leaves, clearly dominate. These local materials are certainly abundant, inexpensive, and comfortable from the point of view of heat, but are very short-lived and often fall prey to fire.

In the face of what they regarded as unexploited potential, confidence in a successful outcome prevailed among the research team led by Dr Sandé Oladélé of the Ecole Nationale Supérieure des Travaux Publics (ENSTP) in Yamoussoukro. From the outset, their choice settled on the terra cotta tile which, in the opinion of the experts, "is the coolest and the quietest." However, terra cotta, as comfortable as it is, requires a lot of energy to transform into tile and is therefore expensive.

So the stated ambition of the team was to make a tile that is long-lasting, economical, and accessible to the majority of Ivory Coast's population by making maximum use of local raw materials.

Thus was born the "Vegetable Tiles in Ivory Coast" project, completely funded by IDRC since 1989. The ENSTP researchers are not alone in this new venture. They very quickly furthered the spirit of partnership by becoming associated with the National Research Council of Canada, through its Institute for Research in Construction, based in Ottawa. The Institute, by agreeing to verify the results, accordingly provided a sort of guarantee for the research conducted.

LEARNING LESSONS

At first, the team was able to learn some lessons from the experience of the International Labour Office (ILO), which a few years earlier had introduced in Ivory Coast a tile made from fibre cement, an intermediate material obtained from a mixture of sand, cement, dye, and sisal fibre. These products were all imported, making the manufacturing cost of the tile greater than that of metal roofing materials. In addition to the cost, tiling techniques were not mastered and quality control tests revealed some shortcomings with regard to the strength and impermeability of the sisal fibre tile. Building promoters then became sceptical, and thus slowed down the market acceptance of the product, limiting job creation initiatives.

Armed with the knowledge of all these problems, the "vegetable tile" project team began by orienting its research to emphasize opportunities for using local input. Sisal was therefore replaced with local raw materials such as coconut, rice and even couch grass fibre; less cement was used as the result of a combination of kaolin and vegetable ash rich in silica. The proportions of ingredients were adjusted and a standard was approved in accordance with the requirements of Codinorm, the Ivory Coast agency responsible for standardization. Besides safety, this standard guarantees the quality of the tile.

The equipment required to make the tiles was also made more accessible, with the adaptation of a very affordable mortar mould and a vibrating table that is easily transportable, battery- operated, and price competitive compared to local or imported tables available on the Ivory Coast market. Furthermore, to develop better tile manufacturing and installation skills, training sessions were organized here and there across the country for tile producers and construction workers.

The initial success of the fibre cement tile did not diminish a desire on the part of Dr Sandé's team to continue pursuing goals of economy and quality. In 1992, they developed another type of tile, this time without plant fibres but with coarse sand. It is the same micro-concrete tile, still made from cement, dye and water, but now also containing coarse sand. This innovation is one that meets ecological and economic constraints perfectly, particularly since Ivory Coast abounds in sand pits.

A TILE WITH A FUTURE

Waterproof, long-lasting, reliable, attractive and cost-effective are the key words describing the micro-concrete tile, which was given a helping hand by the devaluation of the CFA franc, increasing sales from 40% to 80%. The country's gains are numerous, since not only does the tile industry provide work for thousands of people today in Ivory Coast, but it also clearly reduces the major outflow of currency to pay for imported building materials. At the same time, architects are more than accepting of the new product, praising the tile for its functional and esthetic features, as well as the way it contributes to harmony and balance. The tile provides more than enough reasons for the people of Ivory Coast to forget their image of a tile that was too often perceived as a vestige of the colonial era.

In order to remain their status as innovators, the ENSTP research team does not plan to stop at tiles. Its plan this time is to create a regional centre dedicated not only to providing information on local building materials, but also to furthering research into different types of concrete and pursuing efforts to discover other materials. Today, Dr Sandé is considering sharing this know-how with countries beyond the borders of Ivory Coast by training tile manufacturers in the region who would agree to adapt the technology and finally "democratize" the tile -- thus enabling the region's countries to find many solutions to their roofing material problems.

Khodia Ndiaye writes for the Public Information Program, West Africa Regional Office, IDRC

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[Vol. 23, No. 4 \(January 1996\)](#)

RIISING FROM THE ASHES

by Denis Marchand

Transforming mountains of ash and coconut shells into building materials is not a fantasy. On the contrary, it is an imminent possibility, as the model house built by the Brazilian Technological Research Institute (IPT) in a densely populated Sao Paulo neighbourhood demonstrates. The mortar used to build the walls consists, in fact, of cement using ash from blast furnaces and vegetable fibre from coconuts. Formerly an encumbrance, these recovered and recycled waste products have become valuable resources for manufacturing prefabricated panels for the construction of single-family dwellings.

Vanderley John, a civil engineer and a member of the research team that developed this technology, enthusiastically vaunts its many virtues. "We started off wanting to recover and recycle industrial waste to manufacture cheap cement, and we succeeded. Now, our objective is to market this technology in Brazil so that the cost of building houses can be reduced and more families can become home-owners. Furthermore, it would not be an exaggeration to say that the social, economic, and technical benefits are as great as the environmental advantages. They are closely linked."

PRODUCT OF LENGTHY RESEARCH

This technology is the product of 14 years' research and experimentation conducted at the IPT with financial support from IDRC. In 1980, Vahan Agopyan, an engineer, began his first research into the use of industrial waste as a reinforcement material, experimenting with asbestos, glass, newspaper and sisal fibres, inexpensive products found in abundance on many Brazilian industrial sites.

He ended up settling on coconut fibre. It is less of a health hazard than asbestos fibre, less expensive than fibreglass, and longer and more efficient than sisal fibre. Combining this vegetable fibre with cement, however, gave rise to a major problem. This fibre, which is sensitive to chemicals and humidity, quickly deteriorates on contact with the alkaline compounds found in conventional cement.

To eliminate this problem, Agopyan surrounded himself with chemists, biologists and engineers. Their research led them to residual cinders from blast furnaces in the metallurgical industries. To extract steel from iron ore, these industries fire their furnaces with coal, lime, carbon dioxide and clay. Combustion of these substances at high temperatures, namely 1,450 C, produces slag containing lime, calcium and silicon -- composites found in Portland cement. This pozzolan ash, however, less alkaline than conventional cement, does not affect the durability of the vegetable fibre. As a result, it is not only a perfect binder for hardening the mortar, but also a cinder cement costing less than ordinary Portland cement.

"In Brazil, as in several European countries, metallurgical slag is recovered by the cement factories. What is new is its combination with vegetable fibres in the manufacture of cement panels used to build single-family dwellings -- technology that our research made it possible to develop," says Vanderley John.

RECYCLING OF INDUSTRIAL WASTE

Brazil is a large steel producer. The furnaces of the five largest companies produce at least five million tons of waste annually. More than half is ground to manufacture Portland cement or crushed for building roads and railways. The other half remains unused. Vanderley John estimates that recovery of this much waste would make it possible to build about 400,000 houses.

Today, the steelworks prefer to market this type of waste and earn a profit from it. "Our technology provides them with a new opportunity to sell the residual ash cheap."

This technology would also enable the agro-food processing industry to get rid of the two million tons of fibrous shell collecting annually in its dumps.

ANSWER TO HOUSING NEEDS

If the recovery and recycling of available resources has obvious ecological repercussions, it also has some significant social benefits. Unfortunately, for lack of financial resources, the Brazilian government, which is grappling with a huge housing shortage, has imposed drastic cuts in social areas and its financial assistance programs for families wishing to acquire their first home. "In this context, we expect it will be easy to market our technology to meet the growing housing demand in urban settings and the needs of the middle class, which is gradually getting poorer. Especially when it accounts for an 11% savings compared to the price of a house the same size built from ordinary Portland cement blocks or clay bricks. Which is considerable," notes the engineer.

Realizing that this technology represents a major contribution to the building industry, Vanderley John never misses an opportunity to promote it among political authorities in charge of housing at the federal and municipal levels, among architects, engineers, and small builders and producers of pre-fabricated materials. Optimistic and convinced, he does not hesitate to conclude in these words: "Our prototype is modest and comfortable. The strength and durability of the materials, tested at length, are no longer in doubt. Each house is made of 70 cement panels. Small businesses could manufacture the panels themselves, assemble them and make a profit with three building starts a day. In the medium term, this technology could be applied to constructing apartment buildings, as confirmed by ipt engineers, who are ready to coach any interested business people. It is realistic to hope the technology will be put to use in the fairly near future.

Denis Marchand, a Montreal journalist, reported from Brazil.

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[Vol. 23, No. 2 \(July 1995\)](#)

HOUSING SOLUTIONS: FOR VIETNAM'S CITIES

by Daniel Girard

In the slum areas crowding the canals of Ho Chi Minh City, Vietnam, a powerful smell is the first unavoidable sensation. The odour of rotting garbage and untreated sewage confronts the visitor even before the rows of wooden huts come into view.

A closer examination reveals dwellings with galvanized steel or timber roofs, chainlink or straw mat walls covered with cardboard or thin wood and a bare wood or dirt floor. Heavy rains and wind easily push their way into the simple homes, which are literally a roof over the head for tens of thousands of people. In the dark brown canal waters flowing outside, plastic containers and tin cans mingle with human and other wastes dumped from the huts.

Although it may seem an unlikely place to call home, that is exactly what an increasing number of Vietnamese are doing. Driven by the hope of jobs and a better standard of living, more and more people are leaving the countryside for the cities. But with about one-quarter of the current population unemployed, newcomers are unable to find work, surviving on part-time jobs and swelling the slum population.

The number of people coming to the city is increasing and we are unable to stop it, said Prof. Hong Dao, deputy director of the Architecture University in Ho Chi Minh City (formerly Saigon). Dao said he could not estimate how much the city's poor population has swelled in recent years. But up-to-date data collected as part of an IDRC-funded project to improve the shelter and environment of the country's urban poor show that about 320,000 people, or some eight percent of the city's four million inhabitants, live in slums.

The definition of a slum area is one where the homes are made of temporary materials such as galvanized steel roofs, straw or thin timber walls, wood or dirt floors and have no plumbing or electricity, he said. In Ho Chi Minh City, there are 24,000 such dwellings on canals alone. The government and local authorities are trying to start their clean-up efforts along these canals, Dao added in an interview through an interpreter.

In addition to the Ho Chi Minh City Architecture University, three other Vietnamese institutions are participating in the project: the Hanoi Architecture Institute, the National Institute of Urban and Rural Planning, and the Institute of Sociology. There is coordination and consultation among the institutions but each carries out its own research and works independently, Dao said.

Pressures of urban migration

Vietnam's communist government decided in 1986 to pursue a market-oriented economy, paving the way for foreign investment under a policy called doi moi or openness. That has meant the government has

pulled out of many aspects of urban development at a time when the pressure from urban migration has greatly increased. The quality of shelter and basic services for the poor is increasingly of concern to officials.

In Ho Chi Minh City, the living conditions of the poor represent more than just a housing problem, Dao said. At low tide, the untreated sewage originating in the slums flows down the canals, into the Saigon River and is carried out toward the South China Sea. But at high tide it flows back up the river and canals. The water is not the city's main supply but it is used by those inhabiting the slums. The canal areas are producing terrible pollution for the whole city and it's one of our priority problems, Dao said.

Unfortunately, the many years of Vietnam's international isolation mean the country faces a knowledge gap in trying to find solutions to housing and environmental problems such as those in its urban slums. The first step in recovering the missing information was to begin collecting data in 1993 to define the slum areas and determine in greater detail the living conditions of the people there, Dao said. Among their findings, the researchers discovered that the average monthly salary of slum workers is between us\$15 to us\$20. Typically, the slum dwellers can only find casual work as artisans, labourers or cyclo-taxi drivers, he said.

In this initial stage of the project, researchers from the Urban Institute of the University of Montreal, led by Prof. Ren, Parenteau, helped explain what data needed to be collected and how the research should be carried out, Dao said.

This process of education and sharing of ideas are central elements of the project. In addition to improving the living conditions and environment of the residents of Vietnamese slums, another goal of the project is to immerse the country's researchers in new methodologies as a training exercise for future projects. The multi-disciplinary approach with the involvement of social scientists, architects, and urban planners will also increase the potential impact of the project.

The Vietnamese researchers have also had the opportunity to learn from international examples in the field of urban housing. Some project participants have been able to visit housing agencies, non-governmental organizations and other relevant institutions in nearby countries to see how similar problems there have been addressed. It is hoped that through such intra-regional contact for many of the Vietnamese their first opportunities to travel outside their country more international co-operation will evolve in the future.

It is also clear that this project will influence not only Vietnamese research methods, urban environment and government policies but also the future of urban planning in the country. All urban planners and architects in the country must first train at either the Hanoi Architecture Institute or the Ho Chi Minh City Architecture University. Therefore, the lessons learned through this project will have an impact on the course material for students in the years ahead.

Notwithstanding these long-term impacts, Dao said the more immediate focus of the project is on improving the housing and environment of the urban poor in Ho Chi Minh City and Hanoi. The initial focus of rehabilitation activity will be on a few of the canals in Ho Chi Minh City and in Hanoi. But Dao said the lessons learned in those places will be useful elsewhere in Vietnam. We have a lot of other cities with slums on canals so what we learn here we can use throughout the country, he said. And in addition to the canal slums there is poor housing in other cities that will likely be improved by the solutions found in this project, Dao added..

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[Vol. 21, No. 4 \(January 1994\)](#)

Buildings That Take the Heat: Fire-Resistant Housing in China

by Jennifer Pepall

Fire-related deaths and injuries are increasing at a rate of 20% a year in China, an alarming statistic that is partly owing to the mushrooming of highrise residential buildings in Chinese cities. These highrises are often poorly built fire traps made of highly flammable materials.

New safety standards, however, have been adopted by the Fire Bureau of China's Ministry of Public Security. These standards, the outcome of a joint Chinese-Canadian research project, may help save thousands of lives by enabling the construction of fire-resistant housing.

China's economic reforms have led to increasing urbanization and an accompanying demand for cheap housing. Residential construction has shot up to accommodate this demand; between 1984 and 1985, China experienced a 60% rise in investments in housing construction.

Shenzhen, a city in southeastern China, illustrates the building boom. In 1980, Shenzhen housed a few thousand farmers growing produce for Hong Kong. Today, the population is 2 million. About 300,000 workers live in company-owned highrises. These hastily erected buildings deteriorate in seven to eight years compared with a rate of decline of 40 years in the developed world.

Fires in such buildings spread rapidly through walls and floors, enveloping a structure within minutes. These fires also jump easily to other structures, multiplying the risk of death, injury, and property damage. The most recent Chinese statistics show that in 1990, fire accidents caused 2,100 deaths, 4,700 injuries, and CA\$114 million in damages.

Fire-resistant construction techniques can help reduce the impact of fire accidents. A four-year project, undertaken by China's Tianjin Fire Research Institute (TFRI) and Canada's National Fire Laboratory of the National Research Council, has provided the means for such construction. Researchers in this IDRC-funded project have developed equipment, testing methods, and standards for fire resistance. The goal, said T.T. Lie, Principal Research Officer at the National Fire Laboratory, was to help his Chinese colleagues acquire "all the means to evaluate fire resistance and to carry out further research."

Such research can be easily applied to building safe, affordable housing. "The best approach is to use structural materials for safety and to build structures sufficiently strong to withstand fire," says Kenneth Richardson, Head of the National Fire Laboratory.

UNIQUE FACILITY IN CHINA

Members of the project designed and built furnaces for evaluating the fire resistance of building components such as brick, concrete, and steel. The furnaces simulate fire conditions as well as the weight borne by walls, floor-beam assemblies, and columns in a structure.

Project researchers designed and built a new column test furnace at TFRI and upgraded the existing wall and floor-beam furnaces at the institute. With its improved and new capabilities, TFRI is the only facility of its kind in China.

In order to save on expensive furnace testing, researchers devised mathematical models to evaluate the fire resistance of certain columns, slabs, and beams made from commonly used Chinese building materials. These models provide an alternative to full-scale testing that is cheap, fast, and accurate.

The project has enabled TFRI to establish standards for methods of testing the fire resistance of construction assemblies. These standards are now being implemented by the Fire Bureau of the Ministry of Public Security in China. "(They) give the government a powerful tool to use in fire-safe construction," says Richardson.

In addition to realizing its objectives in fire resistance testing and evaluation, the project provided opportunities for technology transfer and the training of Chinese scientists at Canada's National Fire Laboratory. Moreover, the improved facilities at TFRI will enable Canadian researchers to corroborate their own findings on fire resistance.

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[Vol. 21, No. 4 \(January 1994\)](#)

Constructing Egyptian Alternatives: Shale Brick Production in Egypt

by Craig Harris

Underneath the steady glare of the relentless Egyptian sun, workers toil on the banks of this country's famed water source, the Nile River. They mould bricks from top soil and Nile silt and then heat them in the smoking kiln, dancing gingerly on the roof to make sure the fruits of their labours are shaped and stored properly. The workers are engaged in the hectic, competitive trade of making and supplying bricks to Egypt's construction industry.

"These workers and the raw materials they use are the cornerstones of Egyptian small-scale brick production," says Dr. M. Ramez of the General Organization for Housing, Building and Planning Research (GOHBPR) in Egypt, a government research organization. Although labour and Nile silt have traditionally been the cornerstones of brick-making, both have suffered from recent changes and problems within the industry.

The limited availability of prime land around the Nile and the fierce competition over this precious resource forced the Egyptian government to ban the use of agricultural land for brick production in the mid-1980s.

When brick companies took the top soil and silt from the land, as they did throughout the 1970s and early 1980s, they rendered it almost useless for agricultural production. The soil degradation and setbacks in agricultural productivity were simply too high a price to pay for allowing brick producers to use the land, the Egyptian government decided.

But the government's ban had human costs as well. Dr. Ramez and fellow researchers estimated that by 1987 about half of the 2,600 small-scale brick plants were shut down owing to a shortage of raw materials. Almost 130,000 people lost their jobs as a result. There were also other effects, such as construction slowdowns that hit the poorer groups in Egyptian society who desperately required low-cost housing.

With the assistance of IDRC, Dr. Ramez has worked towards solving the dilemma facing Egyptian small-scale brick producers through a project called shale brick production. He and his fellow researchers have concentrated their efforts on alternative, more abundant Egyptian natural resources for brick production. One material, known as shale, has been an increasingly effective substitute for Nile silt.

ABUNDANT ALTERNATIVE

Shale is what geologists refer to as a "semi-consolidated rock" made of fine grained aluminous materials, generally clays. Shale can be found in the desert and along the Nile, where it forms rock outcrops over which it is impossible to farm. The material is abundant researchers have estimated that there are about 500 million cubic metres of shale in the desert and along the Nile River -- but it is less suited to brick-making

than the top soil and silt. It still needs further refinement if it is to assist small-scale brick producers in their quest for new raw materials, Dr. Ramez notes.

This straining of demand against natural resources is nothing new in Egypt. In a country with limited arable land and a population that has increased from 16 million people to over 50 million in the past fifty years there is bound to be fierce competition over limited basic resources.

The construction industry has been a classic example. The demand for housing and construction has risen dramatically over the past twenty years. To keep pace, the production of bricks has jumped from 2.7 billion units in 1976 to 5 billion in 1981 to almost 10 billion in 1986.

Farmers with land on the Nile started to rent their land to brick companies in return for quick money. But the implications were serious. Unsustainable exploitation by the brick companies pushed the issue of land availability along the Nile to a head.

When the ban was announced by the government in 1984, some companies ignored it and tried to remove silt and top soil from the land surrounding the Nile in secret, as if it were precious gold. The penalties were stiffened from fines to jail sentences. Clearly, it was a no-win situation that called out for developing new materials to make bricks.

At this stage, Dr. Ramez and the GOHBPR stepped forward. As early as 1977, Dr. Ramez had succeeded in developing a prototype for brick production using shale as the raw material. He tried to maintain the basic infrastructure of traditional brick-making, realizing that major technological changes would be difficult to introduce.

"It was an efficient pilot-scale plant but it closed after two years," he says. "At that time, few were really interested in new techniques of brick production." It wasn't until the government decree that companies were forced to either try alternative methods of production or face closure. By 1986, when enforcement of the ban was becoming very strict, more than 500 plants modernized and switched to using shale as the raw material for brick production.

"Although this was a positive sign, there were still many setbacks at this stage," Dr. Ramez recalls. Owing to increasing demand, many small-scale plants zealously over-produced without paying attention to the physical limitations of the shale. This resulted in inferior-quality bricks. "If you held up some of these bricks they would crumble in your hands," Dr. Ramez says. Indeed, the standard measure of brick strength (kilograms per square centimetre) revealed a generally poor quality in most of the bricks of only 10 to 15 kg/cm².

Early in the research, Dr. Ramez and fellow researchers at GOHBPR recognized the physical limitations of shale in brick production. The presence in the shale of a peculiar clay mineral called montmorillonite caused excessive swelling and shrinking when it was made into bricks. In addition, high levels of sodium chloride (salt) in the shale contributed to the cracking of bricks upon drying. The salt also corroded equipment in the brick plants.

OVERCOMING SHALE'S LIMITATIONS

To counteract these problems, researchers have been experimenting in mixing shale with materials such as slag, heated clay, lime and carbonates to reduce the shrinking and cracking of the bricks. An added challenge was to find technology for producing bricks that would be as low cost as traditional methods.

"One thing I realized from the start is that it is very difficult to change traditional production patterns," says Dr. Ramez. "These production patterns in the brick-making industry are still very labour-intensive and use little technology, often relying on the sun to dry bricks."

So Dr. Ramez and researchers at GOHBPR developed a simple production technique that involved

grinding and mixing the shale with other materials, moulding and extruding this into bricks and then drying the bricks until they become hardened. It has been tested at both the GOHBPR site in Cairo and in a pilot plant in Beni Suef, about 60 km south of Cairo.

Dr. Ramez says that many of the small-scale brick producers who have converted over to shale are beginning to take advantage of the project's research results. "We have noted an improvement in the quality of brick that many of these small-scale plants are making," he says. Indeed, the strength of shale bricks has increased from 10-15 kg/cm² to 50-70 kg/cm².

Since 1988, this project has attempted to adapt the production process to environmental circumstances and increase the quality and productivity of small-scale brick plants. "Our immediate objective was to successfully incorporate shale into the brick-making industry," says Dr. Ramez. "But our long-term goal was to ensure the continued viability of small-scale plants for both their employees and the people who relied on them for low-cost housing."

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